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Abstract

CERAMIC-COATED PARTICLE NUCLEAR FUELS

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Ceramic-coated particle nuclear fuels consist of small particles of the fuel material, each coated with a thin layer of an impermeable pyrolytic carbon or other ceramic material, usually dispersed in a graphite or other ceramic matrix. The coatings protect the fuel from chemical reactions, protect the matrix from fission recoils, and provide improved fission-product retention at a high temperature. These fuel materials are of particular interest in gas-cooled reactors.

The steps in the fabrication of coated-particle fuel materials are the fabrication of the fuel particles, their coating with a ceramic layer, and the fabrication of a dispersion of the particles.

Methods capable of producing nearly spherical fuel particles have been emphasized in the work so far. Oxide particles have been produced by sintering methods and the sol-gel process. Carbide particles have been produced by fusion, and by a modification of the sol-gel process.

Fuel particles have been coated with many ceramic materials. The method most commonly used is vapor-phase coating in a fluidized bed. The conditions have been worked out for producing strong, impermeable coatings of carbon, beryllia and alumina, and information obtained on some of the important properties of the coatings.

Gentle methods are required to fabricate ceramic dispersions of these coated particles to avoid cracking of the coatings. Certain fabrication methods have been found to be particularly successful.

Laboratory evaluations of fission-product retention show that losses of the fission gases krypton and xenon are negligible from uncracked coated particles at all practical operating temperatures. The loss of some solid fission products through pyrolytic-carbon coatings is greater than that of the fission gases.

Radiation studies have been directed towards achieving optimum fission-product retention through designing the fuel material so that cracking of coatings does not occur. It has been found that, for both pyrolytic carbon and oxide coatings, a certain minimum coating thickness is required to prevent cracking. Porosity in the fuel particle or the coating is beneficial in preventing cracking and, in the case of pyrolytic carbon coatings, a multilayer coating has also been found desirable. Recent radiation results show that essentially all coating cracking can be prevented with pyrolytic-carbon- or alumina-coated particles, to burnup of 10-20% of heavy-metal atoms, at temperatures up to 1400C. It is more difficult to obtain good performance from BeO-coated fuel materials; ways to make better BeO-coated fuels are being studied.